ABSTRACT OF THE DISCLOSURE

A method of manufacturing improved thin-film solar cells entirely by sputtering includes a high efficiency back contact/reflecting multi-layer containing at least one barrier layer consisting of a transition metal nitride. A copper indium gallium diselenide ($Cu(In_XGa_{1-X})Se_2$) absorber layer (X ranging from 1 to approximately 0.7) is co-sputtered from specially prepared electrically conductive targets using dual cylindrical rotary magnetron technology. The band gap of the absorber layer can be graded by varying the gallium content, and by replacing the gallium partially or totally with aluminum. Alternately the absorber layer is reactively sputtered from metal alloy targets in the presence of hydrogen selenide gas. RF sputtering is used to deposit a non-cadmium containing window layer of ZnS. The top transparent electrode is reactively sputtered aluminum doped ZnO. A unique modular vacuum roll-to-roll sputtering machine is described. The machine is adapted to incorporate dual cylindrical rotary magnetron technology to manufacture the improved solar cell material in a single pass.